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AUTHOR Weaver, Constance L.
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ABSTRACT

This research was designed to investigate several primary questions in comparing the Logo floor turtle to the Logo screen turtle: (1) Do young children gain different geometric concepts from experiences with the floor turtle than they do with the screen turtle? (2) Do young children learn to use the four basic Logo commands more efficiently with the floor turtle than they do with the screen turtle? (3) Do young children prefer interacting with the floor turtle or the screen turtle? (4) Do the children who learn Logo gain more in perspective-taking ability than do the children who do not learn Logo? (5) Do the children who learn a single-key version of Logo in a geometry setting learn more geometry concepts than the children who did not learn Logo? This study included 17 4-year-old and 79 5-year-old children who were members of 5 classes in the suburbs of Buffalo, New York. A four (turtle, screen, paths, control) by four (four different teachers) design was used with planned contrasts for the kindergarten children. The preschool children were placed into either the floor turtle group or the screen turtle group. The initial lessons of Clements' and Battista's Logo Geometry Curriculum (1989) were used to teach Logo and elementary concepts of geometry related to path. The children in the experimental groups averaged two to three computer sessions per week for about 6 weeks. The results of the study were mixed. Significant differences in ability to use Logo were not found between groups, nor did the children show a clear-cut preference for one kind of turtle over another. The children's perspective-taking abilities did not change over the time of the study, and while geometry scores did improve, no significant differences between groups were found on the geometry tests. (Author/KR)

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Young Children Learn Geometric Concepts Using Logo with a Screen Turtle and a Floor Turtle

Constance L. Weaver

State University of New York at Buffalo

CE051951

Abstract

This research was designed to investigate several primary questions in comparing the Logo floor turtle to the Logo screen turtle: (1) Do young children gain different geometric concepts from experiences with the floor turtle than they do with the screen turtle? (2) Do young children learn to use the four basic Logo commands more efficiently with the floor turtle than they do with the screen turtle? (3) Do young children prefer interacting with the floor turtle or the screen turtle? (4) Do the children who learn Logo gain more in perspective-taking ability than do the children who do not learn Logo? (5) Do the children who learn a single-key version of Logo in a geometry setting learn more geometry concepts than the children who did not learn Logo?

This study included 17 four-year-old and 79 five-year-old children who were members of five classes in the suburbs of Buffalo, New York. A four (turtle, screen, paths, control) by four (four different teachers) design was used with planned contrasts for the kindergarten children. The preschool children were placed into either the floor turtle group or the screen turtle group. The initial lessons of Clements' and Battista's Logo Geometry Curriculum (1989) were used to teach Logo and elementary concepts of geometry related to path. The children in the experimental groups averaged two to three computer sessions per week for about six weeks.

The results of the study were mixed. Significant differences in ability to use Logo were not found between the children who used the floor turtle and those who used the screen turtle. In addition, when the children were asked which kind of turtle they wanted to work on, the floor turtle was chosen 74 times and the screen turtle was chosen 77 times. Consequently it was concluded that young children can learn to use Logo equally effectively with either style of turtle. None of the children changed in their perspective-taking abilities over the time of the study. The part of the Logo curriculum used in this study did not penalize children for entering the wrong turn command, and the children learned very quickly how to "undo" the wrong command. The children seemed to have infinite patience with the turtle, and were not the least bit concerned with efficiency of movement. The geometry scores did improve and significant differences were found within subjects between the pretest and the posttest. Because of several contributing factors, significant differences between groups were not found on the geometry tests. The conclusion is that this research did not resolve the research questions related to geometry.

Clements, D. H., & Battista, M. T. (1989). Logo-based elementary school geometry curriculum:Interim report. Unpublished manuscript.

Young Children Learn Geometric Concepts

Using Logo with a Screen Turtle and a Floor Turtle

Introduction

Logo is a popular programming language that, though very powerful in the hands of an experienced user, can produce exciting results for inexperienced users the first time they attempt it. This is because Logo has an interactive graphic mode that allows a user to enter a command and watch an icon (i.e. a "turtle") on the screen perform the command and in addition, leave a line on the screen that marks the path it traveled. There are four basic Logo graphics commands: FORWARD; BACKWARD; RIGHT; and LEFT. When entering each command, an argument must also be entered to indicate the distance to move (i.e. forward 30 or backward 5) or the degrees to turn (i.e. right 90 or left 15). Armed with these four commands, novice users can create very interesting designs on a computer screen.

In addition to the screen turtle, Logo may be used to operate a floor turtle. A floor turtle is a robot that has a domed body, a motor, precision wheels, and a pen that can be lowered and raised. It is operated by entering Logo commands at a computer keyboard. Some floor turtles are connected to the computer by a long electric umbilical cord, and some are operated by remote control.

Statement of the Problem

The purpose of this research was to investigate if young children learn different geometric concepts, and/or develop different levels of competence with a single key Logo language when they are taught geometry using Logo with a floor turtle versus the screen turtle. This research was designed to investigate three primary questions in comparing the floor turtle to the screen turtle:

1) Do young children gain different geometric concepts from experiences with the floor turtle than they do with the screen turtle?

2) Do young children learn to use the four basic Logo commands more efficiently with the floor turtle than they do with the screen turtle?
3) Do young children prefer interacting with the floor turtle or the screen turtle?

There is expanding research support for the premise that Logo is an effective tool with which to teach geometry (Clements & Battista, in press; Lehrer, Guckenberg, & Sancilio, 1988). In an effort to expand that body of research, a fourth question was asked:

4) Do the children who learn a single-key version of Logo in a geometry setting learn more geometry concepts than the children who did not learn Logo?

It is felt by some proponents of Logo that experiences with Logo will improve young children's perspective-taking ability. To test this theory, a fifth question was addressed:

5) Do the children who learn a single-key version of Logo improve more in perspective-taking ability than the children who did not learn Logo?

Literature

The use of Logo as an educational tool to help children develop geometric concepts is currently receiving substantial research support. It gained its impetus partially from recent research that reported that there is a need for improvement in the mathematics (and especially geometry) curriculum in the United States. Burger and Shaughnessy (1986) reported that some "secondary school students had incomplete notions of basic geometric shapes and their properties" (p. 46). They stated that if students do not understand basic geometric shapes and their properties enough to reinvent Euclidean Geometry, memorization may be their only recourse (Burger & Shaughnessy, 1986).

In an effort to increase student's understanding of geometry, several researchers have investigated using Logo as a tool to teach geometric concepts to young children (Clements & Battista, 1987; Clements & Battista, in press; Lehrer, Guckenberg, & Sancilio, 1988). According to Lehrer, Guckenberg, and Sancilio (1988), there are multiple ways in which Logo can be used as a tool to restructure children's understanding of geometry. A figure, such as a square, "...may be represented as a path as well as by the more traditional concepts of intersecting line segments" (p. 86).

Research has indicated that four and five-year-old children have difficulty recognizing and implementing Logo commands, yet they are able to deal with the language at a limited level of success (Cuneo, 1985; Howell, Scott, & Diamond, 1987). Several researchers have created versions of Logo that simplify the commands (Clements & Battista, 1989; Cuneo, 1985, 1986; Lehrer, 1989; Roberts, 1984) and a few have made the movements of the turtle more visible by slowing down the rotation (Clements & Battista, 1989) and/or adjusting the turtle steps so that each step is a visible length (Clements & Battista, 1989; Cuneo, 1985, 1986; Lehrer, 1989; Roberts, 1984).

Although the most common method of teaching Logo is by using a monitor with the turtle graphics being displayed on the screen, some teachers and researchers have used a floor turtle to introduce children to the concepts of the turtle (Barnett & Better, 1984; Gregg, 1978; Lehrer and Smith, 1986; Loncar, 1986; Perlman, 1976; Weaver, 1989 a). In a review of the literature, Weaver (1989 b) found that there was no research available that investigated if the floor turtle or the screen turtle makes Logo commands easier to learn or if children gain the same geometry concepts from each experience.

Methodology

Dependent Variables. Five out of six research studies that investigated using Logo to teach geometry concepts employed researcher-created measures of geometric concepts (Clements & Battista, in press; Lehrer & Smith, 1986; Noss, 1987; Rieber, 1983). The sixth study (Barker, Merryman, and Bracken, 1988) did not actually measure geometry concepts with the subjects.

The Clements and Battista geometry pre-post test was revised for this study. The final version consisted of 24 personal interview items designed to determine the children's conceptualizations of angle, shape, and path. The reliability of the revised geometry test was .55 (based on Cronbach's Alpha).

Perspective-Taking Interview. An interview instrument was devised in an effort to determine which children know their right and left, and which are able to take allocentric perspectives. Because Roberts (1984) reported that children are aware of perspectives other than their own at least from the age of two, and some four and five-year-old children do not know their right and left, it seemed important to create a perspective taking task that would test children's ability to take allocentric perspectives without relying on the knowledge of right and left. The interview task was administered to one 2-year-old girl, 10 boys and 9 girls in kindergarten, one girl in first grade, and one in third grade. As a result of those interviews, the procedure was revised and the final form was devised. Using Cronbach's Alpha, the reliability of the right/left instrument was .48 and the reliability of the perspective-taking instrument was .74.

Logo Measures. Three posttest measures were adapted from the Clements and Battista geometry Logo Curriculum. One posttest consisted of a picture of a turtle with an X placed in close proximity to it. The children wrote the command that would make the turtle turn and face the X. A second posttest showed a turtle and between one and three commands. The children drew the path the turtle

would walk if it carried out the commands. Another task was devised to test children's ability to see path-command correspondence.

There were two additional posttest tasks. On the last day of treatment, both experimental groups used the computer to perform a set of exercises in which they were given a pattern on paper and asked to repeat it with the turtle. The commands entered from the last pattern (the shape of a block letter T) were saved and later scored for accuracy. The sixth posttest was a perspective-taking task using four paths and a small seal stuffed animal. The children were asked to use Logo commands to tell the seal how to swim to the fish that was at the end of each path. The researcher recorded all commands. The four paths were designed so that a right and left turn was given at each of the four directional headings (i.e. 0, 90, 180, and 270 degrees). Based on Chronbach's Alpha, the reliability of the Seal Paths instrument was .66.

The following chart recaps the measurement instruments used for the different groups:

Measurement Instrument	Group	Time Administered
Geometry Test	All groups	Pre and Post
Logo Tasks	Logo groups	Post
Perspective-Taking Test	All groups	Pre and Post
Map Navigation Task	All groups	Post
Preference Interviews	Logo groups	Post

Design for Kindergarten Classes. A four (turtle, screen, paths, control) by four (four different teachers) design was used with the following planned contrasts:

1. The two Logo groups were combined and compared to the combined non-logo groups on the geometry test, perspective-taking task, and the map navigation task.

2. The screen groups and the floor groups were compared to each other on all of the dependent variables..
3. The non-logo paths group was compared to the control group on the geometry test, perspective-taking task, and the map navigation task..

Design for Pre-School Classes.

The class was divided into two groups:

1. The screen groups and the floor groups were compared to each other on all of the dependent variables.

Design for Kindergarten and Pre-School Combined.

A two (screen, turtle) by two (4-year-old, 5-year-old) design was used with the following planned contrasts on all of the dependent variables:

1. The main effect of age was analyzed for each of the dependent variables.

Subjects' Ages. While there was no evidence of children under three using Logo, Loncar (1986) found that two out of eight 3-year-olds were able to see the relationship between the modified key commands and the actions of the robot in the first two weeks of their Logo experience. Gregg (1978) reported that most 3-year-old children did not see the relationship between pressing buttons and the movement of the floor turtle. All of the four and five-year-old children were able to see the relationship between the key-press and the turtle activity (Loncar, 1986). Based on the results of this previous research, four-year-old children were the youngest included in this study.

The previous studies that investigated using Logo as a tool to teach geometry all involved children in the second grade or higher. In an effort to discover how young children can be and still learn geometric concepts while using Logo, this study included 17 four-year-old and 79 five-year-old children.

Sampling. The kindergarten Logo subjects were members of two classes in which the teachers were experienced teaching the Logo Geometry Curriculum.

Each class was divided into two experimental groups - one floor turtle group and one screen turtle group using a randomized block design. Two other classes in the school who were not participating in the Logo curriculum, but did attend a computer class each week were divided into a paths group and a control group.

The four-year-old children were members of the pre-school program at a university in Buffalo, New York. The teachers were not experienced teaching the Logo geometry curriculum. The preschool class was divided into two treatment groups - the floor turtle group and the screen turtle group.

A randomized block design was used to assign the children in each Logo class to two experimental groups and also to assign the children in each non-Logo class to a paths group or a control group. A perspective-taking interview instrument was used to assess the children's knowledge of right/left and if they were egocentric (always take own perspective) or allocentric (able to take perspective from another point-of-view) in their perspective-taking ability. Based on the scores from the perspective-taking task, the children were matched into four groups: (a) Do not know right and left and are egocentric in perspective taking; (b) do not know right and left and are allocentric in perspective taking; (c) know right and left, but are egocentric in perspective taking; and (d) know right and left and are allocentric in their perspective taking ability. Each set was then divided between the treatment groups using a random number table.

Treatment

The initial lessons of Clements' and Battista's Logo Geometry Curriculum (1989) were used to teach Logo and elementary concepts of geometry related to path. The curriculum began with discussions about paths and what a path is, followed by the children walking large paths which were mapped out on the floor. Following the path experiences, the children were taught the "Play Turtle" game and the "Turtle Find" game. Up until this point, the curriculum was taught by

the individual teachers in the kindergarten classes, and by the researcher in the nursery school class. The children in the kindergarten paths group participated in the same paths activities and games as the Logo groups, but did not have any Logo computer experiences. The Logo classes worked on the computer part of the Logo curriculum on alternate days. In an effort to reduce the teacher effect as much as possible, the kindergarten teachers and the researcher alternated teaching groups each day. The researcher taught all of the preschool sessions. The children in the experimental groups averaged two to three computer sessions per week for about six weeks.

The children in the floor turtle group worked only with the floor turtle. A Valiant Turtle was used on the floor on sheets of paper which measured about 4 feet by 6 feet. The turtle had a pen in the down position so that it would leave a path mark everywhere it went. The children in the screen turtle group used a version of Logo which slowed down the speed of the turtle so it was easier to see the turtle moving on the screen than do regular versions of Logo. In addition, both groups used a single key version of Logo which allowed them to enter an "R" to make the turtle turn right 90 degrees, an "L" to turn left 90 degrees, an "F" to go forward ten steps, and a "B" to go back 10 steps. About half way through the research, the turns were changed to 45 degree turns. This appeared to be a difficult adjustment for many of the children in both the kindergarten and preschool classes.

Since both treatment groups (floor and screen) were in each class, care had to be taken to ensure that the children assigned to the screen turtle group did not have the opportunity to watch the floor turtle group working. For the kindergartners, this was accomplished by providing the whole-class explanations in the classroom using a screen projector which projected the computer display on the wall. Two other computers for the screen group were set up in the hall

outside of the classroom, and the floor turtle system was located down the hall out of view from the children entering and exiting their classrooms. The preschool children did all of their computer work in a separate room which made it easier to control their experience.

The children worked in pairs. One pair from each group was videotaped each day. The tapes were assessed for errors per task and for conversation exchanges and body motions that would help the researcher infer what the children thought was happening with the turtle. This included the children's ability to predict the turtle's movement (i.e., did they say what they expected the turtle to do? did they act surprised at the movement of the turtle?), if the children were putting themselves in the perspective of the turtle (i.e., did they move themselves to align themselves with the heading of the turtle?), and if the children became pleased or frustrated with the way the turtle system operated (i.e., did the children laugh and talk excitedly? did they act irritated and hit the keyboard, or walk away?). Paper and pencil exercises designed to reinforce the geometry concepts being learned in the Logo environment were provided.

Results

The children's scores on the geometry tests, the perspective-taking tasks, the Seal map test, and the Logo commands tests were analyzed using analysis of variance. The independent measures were the four classroom teachers and the four groups (screen, turtle, paths, control) the children were assigned to. The dependent measures were the scores of the geometry test, perspective-taking test, Logo tasks, map navigation task, and the preference interviews..

In general, all groups scored higher on the posttests than they had on the pretests. In addition, the five-year-olds scored better than the four year olds on most items. Significant differences were found within subjects and between age

levels, but significant differences were not found between groups within age levels.

Geometry Scores. To try to answer the related questions, "Do the children who learn a single-key version of Logo in a geometry setting learn more geometry concepts than the children who did not learn Logo?" and "Do young children gain different geometric concepts from experiences with the floor turtle than they do with the screen turtle?" the scores on the geometry tests were analyzed using analysis of variance.

The kindergarten group means and standard deviations for the geometry pre- and posttests are presented in Table 1. While significant differences were not found between the floor, screen, paths, and the control groups, significant differences were found within subjects between the pretest the posttest.

Table 1

Mean Pre and Post Geometry Scores for the Kindergarten Groups

Group	Logo				No Logo			
Treatment	Floor		Screen		Paths		Control	
Teacher	T1	T2	T1	T2	T3	T4	T3	T4
n	11	9	10	9	9	11	11	9
Pretest								
Mean	62.9	59.3	62.2	58.5	60.8	57.3	63.8	60.2
SD	3.2	7.5	5.4	3.6	6.5	5.8	3.7	7.0
Treat Mean	61.3		60.4		58.9		62.2	
Group Mean	60.9				60.5			
Posttest								
Mean*	67.1	65.9	67.7	65.3	62.7	66.0	62.0	66.5
SD	7.7	6.4	7.7	4.0	6.4	8.0	3.9	8.2
Treat Mean	66.5		66.6		64.5		64.0	
Group Mean	66.5				64.3			

* Significant differences within subjects over time ($p < .05$).

The preschool children showed similar, though lower results on the geometry tests. Significant differences were not found between the floor and screen groups, but significant differences were found within subjects over time. The geometry posttest scores were higher than the pretest scores. The mean scores and standard deviations are presented in Table 2.

Table 2

Mean Geometry Scores for Pre-Post Tests for Preschool Floor/Screen Groups

Treatment	Floor	Screen
n	8	9
Pretest		
Mean	56.9	53.4
SD	7.0	10.2
Posttest		
Mean*	60.5	59.7
SD	5.3	9.1

* Significant differences within subjects over time ($p < .05$).

Logo Scores. In response to the question "Do preschool and/or kindergarten children demonstrate a better knowledge of the Logo language when they learn Logo while using the screen turtle or the floor turtle?" the children's keystrokes on the computer task of drawing a figure in the shape of a block T letter were saved and scored for accuracy. Significant differences were not found between the floor and screen groups. The mean scores and standard deviations for the kindergarten children are presented in Table 3.

Table 3

Mean Logo Scores for Kindergarten Floor and Screen Logo Groups - Posttest Only

	Floor			Screen		
	Teach1	Teach2	Both	Teach1	Teach2	Both
n	11	9	20	10	9	19
Mean	34.2	34.2	34.2	30.9	32.6	31.7
SD	4.9	6.1		2.4	5.8	

The preschool children's mean scores and standard deviations on the Logo tasks are presented in Table 4. The scores for the preschool groups are inflated because the preschool children required a significant amount of help when they were doing the task. Consequently, it would not be appropriate to compare the preschoolers' scores with those of the kindergarten children.

Table 4

Mean Logo Scores for Preschool Floor and Screen Logo Groups - Posttest Only

	Floor	Screen
n	8	9
Mean	31.3	30.6
SD	4.1	3.7

Perspective-Taking Tasks. To try to answer the two related questions: "Are preschool and/or kindergarten children better able to take allocentric perspectives when they learned Logo using the floor turtle than the children who learned Logo using the screen turtle?" and "Are kindergarten children better able to take

allocentric perspectives when they learned single-key Logo than when they did not learn Logo?" the perspective-taking task was administered both before and after the treatment. Significant differences on the pretests and the posttests were not found between groups or within subjects. Table 5 presents the means and standard deviations for the kindergarten children's scores.

Table 5

Mean Pre and Post Perspective Taking Scores Kindergarten Groups

Group	Logo				No Logo			
Treatment	Floor		Screen		Paths		Control	
Teacher	T1	T2	T1	T2	T3	T4	T3	T4
n	11	9	10	9	9	11	11	9
Pretest								
Mean	3.1	3.2	3.3	3.2	2.9	3.5	2.2	3.2
SD	1.8	1.9	1.9	1.9	1.6	1.6	1.8	1.6
Treat Means	3.1		3.3		3.2		2.7	
Group Means	3.2				2.9			
Posttest								
Mean	3.2	2.8	3.4	3.2	2.9	3.8	2.0	3.2
SD	2.3	2.1	2.2	2.1	1.7	2.0	2.0	2.3
Treat Means	3.0		3.3		3.4		2.5	
Group Means	3.2				3.0			

Note. A perfect score was six.

Table 6 presents the perspective-taking scores and standard deviations for the preschool children. Significant differences were not found between groups or within subjects from the pretest to the posttest.

Table 6

Mean Pre and Post Perspective Taking Scores for Preschool Groups

	Floor	Screen
n	8	9
Pretest		
Mean	2.3	2.7
SD	1.4	1.6
Posttest		
Mean	3.4	2.8
SD	1.7	1.9

Note. A perfect score was six.

Screen versus Floor Preferences. To answer the question "Do preschool and/or kindergarten children express a preference for working with the floor turtle or the screen turtle after they have had experience with both?" the children were asked to tell their preference on two different occasions. Significant differences were not found between any of the groups.

The screen turtle was chosen a total of 77 times, the floor turtle a total of 74 times. The option of no preference was chosen 5 times. There were some occasions when a child would not answer the question or was not available for the interview.

Conclusions and Implications

Unfortunately, this research could resolve only the question concerned with young children's preferences for the screen turtle and the floor turtle. The other questions addressed in this study were not resolved.

Although there were significant differences on the children's scores between the pretest and the posttest, significant differences were not found between the children who were taught the Logo geometry curriculum and those who were not taught Logo. One explanation may be that the Logo treatments were of very short duration, and the experience of taking the geometry intrerviews two times may have had a more profound effect on the children's geometric thinking than did the six Logo experiences. This could indicate that children as young as five years old can benefit from geometry instruction, whether it is on the computer or off.

A review of the video tapes, and the results of the children's preferences, leads me to believe that young children can learn Logo using either the floor turtle or the screen turtle. Several researchers implied that young children would relate better to the floor turtle because it operates in the same space that the child does, and therefore is easier for young children to relate to. My experience with the children in this study leads me to believe that this is not true. I think the children can relate equally well to both turtles. Some expressed the opinion that they liked the floor turtle better because it was easier to see the floor turtle move. Others said they liked the screen turtle because it was easier to just look up at the screen than it was to keep looking over to where the floor turtle was.

In reflecting back, it is not surprising that no group of children improved in their perspective-taking abilities. The children were not concerned if they put in the wrong turn command, because they very quickly learned how to compensate. Even the preschoolers knew that a right command would "undo" a left command. In addition, the children were very patient. It did not seem to bother them to have

to watch the turtle turn the wrong way before it turned the correct way. Perhaps a Logo game which required the children to put in the correct turn command would help them improve their knowledge of right and left and their perspective-taking ability (this type of game is in the curriculum we used, but we did not progress to that stage during the research study).

The children in the Logo groups were fairly evenly divided between preferring the screen turtle and the floor turtle. The children were asked why they preferred one or the other. Many times the reason given was that they had used one of the turtles more frequently, and wanted to use the other one now, or they had used one yesterday and wanted to use the other one today. While most of the children did not have strong preferences for one turtle or the other, few children in each group expressed a firm preference for one of the two turtle types.

The kinds of reasons given for preferring the screen turtle were: It's easier to use, it's faster, it's easier to see, it makes patterns on the screen.

The kinds of reasons given for preferring the floor turtle were: It's easier to use, it is slower and easier to see it move, you can touch it, you can make better patterns with it.

Summary

Young children can learn a single-key version of Logo using either the screen turtle or the floor turtle. The children liked both styles of turtle and generally gave the appearance (from the video tapes) of enjoying their time working with the Logo Geometry curriculum. This research did not resolve any of the other questions it asked. The measurement instruments need to be revised, and perhaps new ones selected to provide a higher level of reliability. It is apparent from the geometry test scores, that when geometry concepts are taught to young children, whether on the computer or not, the children will gain knowledge of geometry.

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